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Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/508
ISRAEL
February 1964
Submitted in: ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

GUIDE FOR THE HAZARDS EVALUATION OF A CHEMI-NUCLEAR INSTALLATION

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Experience acquired in operating nuclear installations shows that in spite of the potential hazards of this industry, its safety record ranks among the highest prevailing in the industrial field. This result has been achieved by the incomparable efforts made to recognize the hazards of nuclear installations, to avoid the occurrence of failures and accidents and to minimize the possible effects of an accident, should it occur.

The hazards evaluation study made prior to the construction and operation of a nuclear plant, which has been adopted as a standard procedure, is an example of the particular efforts made in the nuclear safety field.

The numerous reports published on the hazards evaluation of nuclear reactors as well as the guides for formulating them, e.g., that of Ablitt [1], enable recognition of the general safety problems encountered in their operation. However, only relatively few hazards evaluation reports have been published for chemi-nuclear plants, for example, those cited [2,3], despite the relatively high potential hazards entailed and their probability.

A study of the environmental hazards involved in the operation of a typical chemi-nuclear installation, based on the "maximum credible accident concept" is presented and compared with the environmental hazards of a nuclear reactor.

A review of accidents in nuclear plants [4] reveals that most of them occurred in chemi-nuclear installations. Also, because of the variety of safety problems encountered, the few hazards evaluation reports published for such installations cannot be used as a general guide.

In the present guide is discussed the general information required for a

hazards evaluation study of a chemi-nuclear installation, and which should be considered in planning the safety precautions for such plants. Consideration is given to two safety concepts: nuclear and chemical safety. Among the topics on which information is required for the hazards evaluation study are the following:

Site evaluation. Materials of construction and resistance of the installation to fire, pressure and shock waves. Auxiliary installations (ventilation, filtration, monitoring system, emergency systems, etc.). Study of the different processes (chemical, metallurgical), of the conditions of operation (temperature, pressure, etc.) and of the materials involved and their properties (e.g. radioactivity, pyrophority). Control system. Maintenance and operation. Storage, transportation and waste disposal. Shielding and containment. Personnel organisation and responsibilities. Possible accidents (fire, explosion, criticality, earthquake, etc.) and their consequences. Evaluation of hazards during normal and continuous operation and following accidents. Emergency procedures.

Special consideration is given to various features of chemi-nuclear plants which differentiate them from nuclear reactors from the safety standpoint, such as high volume specific activity of materials, presence of inflammable and explosive materials, variety of operations involved and the impossibility of providing the installations with the same degree of containment as in nuclear reactors.

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STUDIES OF NEUTRON THERMALIZATION BY A MODIFIED PULSED SOURCE TECHNIQUE

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The conventional pulsed-source technique has been extensively used as a source of information on the thermalization processes of neutrons in moderating assemblies. This information is derived from the "diffusion cooling" coefficient obtained in pulsed source experiments. There are large discrepancies between the results given by different authors [1], while some of the theoretical limitations of the use of "diffusion cooling" measurements as a source of thermalization data were formulated in 1958 [2].

A new method for measuring neutron thermalization parameters that has been proposed on theoretical grounds [3] was tested experimentally in the present work. The theory is extended and results are presented in closed forms. The experiment was performed on H_2O, as the method in its present form is most suitable for the study of homogeneous systems in which strong "non $\frac{1}{v}$" absorbers can be dispersed.

The experimental set-up is described, and details are given of the geometrical arrangement used to suppress some of the higher "harmonic modes". Details of two special methods for the analysis of experimental results are given. These methods

enable the use of data taken at quite short delays after the burst of fast neutrons.

The neutron thermalization parameters in the present formulation are:

$$\gamma_{ij} = \int_0^\infty \int_0^\infty \frac{E}{T^2} e^{-E/T} \Sigma_s(E \rightarrow E') \left[L_i^{(1)}\left(\frac{E}{T}\right) - L_i^{(1)}\left(\frac{E'}{T}\right) \right] L_j^{(1)}\left(\frac{E}{T}\right) dE dE'$$

where T is the temperature of the system in energy units, E is the energy of a neutron, $\Sigma_s(E \rightarrow E')$ is the macroscopic cross section for scattering of a neutron of energy E into a unit energy interval at E', and $L_i^{(1)}\left(\frac{E}{T}\right)$ are the associated Laguerre polynomials of order unity and degree i. The results for H_2O at 23°C can be described by $\gamma_{11} = (0.210 \pm 0.026)$ cm^{-1}. This result differs significantly from results obtained by "diffusion cooling" measurements, and from calculated values based on Nelkin's model for H_2O [4]. These discrepancies are discussed, as well as the feasibility of the method for the study of different systems.

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NUCLEAR CROSS SECTIONS FOR FAST REACTORS

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The 16-group YOM cross section set for fast reactor analysis has been widely used by fast reactor centres during the last three years. Since its publication at the end of 1960 [1], a considerable amount of experimental results as well as related theoretical investigations have become known. Many comments and queries on the different cross sections as well as requests to enlarge the energy range for both higher and lower energy neutrons have been received. It has become necessary therefore to re-examine the YOM set and extend it to include the new developments, both experimental and theoretical, and also to widen its energy range in order to facilitate analysis of problems where higher and lower energy neutrons become of importance.

A revised 16-group cross section set will be presented where account will be taken of:-

(a) New information on neutron angular distributions [2]
(b) Modified inelastic scattering matrices necessitated by different nuclear temperatures and statistical model calculations [3]
(c) Modified capture cross sections of the fissile nuclides
(d) Modified ν-values of U^{235}
(e) Various modified cross section values where errors and ommissions have been found during the last three years.

An extension of the 16-group set to a 20-group set by adding 4 groups in the 2 - 14 MeV range will also be presented. This permits the consideration of reactions which are neglected in current practice and which are of importance in the MeV range.

These are the (n,p), (n,α) and (n,2n) reactions. A detailed study of the MeV range, extending up to 14 MeV, will facilitate analysis of experimental results obtained with pulsed neutron sources. A finer group structure above the U^{238} fission threshold enables study of the fine structure of the flux in this region.

Another extension of the YOM set, below the present boundary of 0.5 KeV, is in progress. This will enable spectrum analysis of neutrons in the large fast reactors under consideration now, in blankets and in Doppler calculations. The lower energy extension, however, will be presented elsewhere.

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